MODIS Level 2 IMAPP Atmospheric Science Processing Algorithm (IMAPP_SPA) User's Guide

Version 3.1

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GODDARD SPACE FLIGHT CENTER
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MODIS Level 2 IMAPP Atmospheric Science Processing Algorithm

IMAPP_SPA

General

The NASA Goddard Space Flight Center's (GSFC) Direct Readout Laboratory (DRL), Code 606.3 developed this software for the International Polar Orbiter Processing Package (IPOPP). IPOPP maximizes the utility of Earth science data for making real-time decisions by giving fast access to instrument data and derivative products from the Suomi National Polar-orbiting Partnership (SNPP), Aqua, and Terra missions and, in the future, the Joint Polar Satellite System (JPSS) mission.

Users must agree to all terms and conditions in the Software Usage Agreement on the DRL Web Portal before downloading this software.

Software and documentation published on the DRL Web Portal may occasionally be updated or modified. The most current versions of DRL software are available at the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/?id=software

Questions relating to the contents or status of this software and its documentation should be addressed to the DRL via the Contact DRL mechanism at the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/?id=dspContent&cid=66

Algorithm Wrapper Concept

The DRL has developed an algorithm wrapper to provide a common command and execution interface to encapsulate multi-discipline, multi-mission science processing algorithms. The wrapper also provides a structured, standardized technique for packaging new or updated algorithms with minimal effort.

A Science Processing Algorithm (SPA) is defined as a wrapper and its contained algorithm. SPAs will function in a standalone, cross-platform environment to serve the needs of the broad Direct Readout community. Detailed information about SPAs and other DRL technologies is available at the DRL Web Portal.

Software Description

This DRL software package contains the MODIS IMAPP_SPA (International MODIS/AIRS Processing Package SPA). The IMAPP_SPA processes MODIS Aqua and Terra Level 1B data into six Level 2 MODIS atmospheric products: Cloudmask (MOD35); Cloudmask First Byte; Cloudtop Properties, Cloud Phase and Cloud Optical properties (MOD06); Atmospheric Profiles (MOD07); Aerosol (MOD04); and Aerosol 3km (MOD04_3K). The SPA functions in two modes: Standalone, or as an IPOPP plug-in.

Software Version

Version 1.3 of the DRL algorithm wrapper was used to package the SPA described in this document. The IMAPP_SPA has been ported from IMAPP Version 3.1 (18th March 2015). This SPA represents MODIS Collection 6.

Enhancements to this SPA include:

a) Update of all NASA science algorithms to MODIS Collection 6. The datasets and metadata contained in the output science products now match the official NASA Collection 6 data products. The science products include Cloudmask (MOD35), Cloudtop Properties, Cloud Phase and Cloud Optical Properties (including Cloud Optical Thickness and Cloud Effective Radius) (MOD06), Atmospheric Profiles (MOD07) and Aerosols (MOD04 and MOD04_3K).

b) Addition of the new NASA Aerosol Dark Target 3 km (MOD04_3K) product. This product offers higher resolution than the standard 10 km Aerosol (MOD04) product and is useful in resolving local scale aerosol features.

c) Inclusion of NASA Deep Blue algorithm outputs (in addition to the Dark Target algorithm output) in the Aerosol (MOD04) product. The Deep Blue algorithm was developed to retrieve aerosols over bright land areas. Together, the two algorithms provide a more spatially complete view of aerosols.

d) Addition of a Cloudmask First Byte product. This product stores original bit values as two-byte integers and is easier to read than the standard Cloudmask product.

e) Addition of a preprocessing step that improves Aqua MODIS band-to-band registration and product quality. The pre-processing step re-registers the 250m bands (Bands 1 and 2) with the other spatial resolution bands in order to meet science specifications. For details about the Aqua instrument band-to-band registration, please refer to: Xiong, Xiaoxiong, et al. "Status of Aqua MODIS spatial characterization and performance." Remote Sensing. International Society for Optics and Photonics, 2006.

f) Update to the Terra MODIS Infrared Band destriping coefficient file to support destriping of sensor data after 2008-06-27. The correct destriping coefficients are chosen automatically. This update improves destriping of Terra MODIS Infrared bands (Bands 25, 27 and 26) and consequently improves the quality of Terra Atmospheric products that use the infrared bands.

This software will execute on a 64-bit computer and has been tested on computers with 32GB of RAM, with the following operating systems:

a) Fedora 20 X86_64;

b) CentOS 7 X86_64;

c) OpenSUSE 12.1 X86_64;

d) Kubuntu 14.04 X86_64.

Credits

The IMAPP software package was developed by the IMAPP Team at the Space Science and Engineering Center (SSEC), University of Wisconsin-Madison.

Prerequisites

To run this package, you must have the Java Development Kit (JDK) or Java Runtime Engine (JRE) (Java 1.6.0_25 or higher) installed on your computer, and have the Java installation bin/ subdirectory in your PATH environment variable.

Program Inputs and Outputs

Inputs to the IMAPP_SPA are as follows:

  a) the MODIS 1km, half km, and quarter km L1B Calibrated Geolocated Radiances Hierarchical Data Format (HDF) products;

  b) the MODIS Geolocation HDF product;

  c) ancillary files for leapsec, utcpole, ice/snow extent, sea ice concentration, sea surface temperature, ozone, clear sky radiance bias, and meteorology.

The IMAPP_SPA outputs the following atmospheric products:

  a) MODIS Cloudmask Level 2 (MOD35);

  b) MODIS Cloudmask First Byte Level 2;

  c) MODIS Cloudtop Properties, Cloud Phase and Cloud Optical Properties Level 2 (MOD06);

  d) MODIS Atmospheric Profiles Level 2 (MOD07);

  e) MODIS Aerosol Level 2 (MOD04);

  f) MODIS Aerosol 3km Level 2 (MOD04_3K).

Installation and Configuration

Installing as a Standalone Application:

Download the IMAPP_3.1_SPA_1.3.tar.gz, IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz (optional), and IMAPP_3.1_SPA_1.3_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the IMAPP_3.1_SPA_1.3.tar.gz, IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz and IMAPP_3.1_SPA_1.3_testdata.tar.gz (optional) files:

```
$ tar -xzf IMAPP_3.1_SPA_1.3.tar.gz
$ tar -xzf IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz
$ tar -xzf IMAPP_3.1_SPA_1.3_testdata.tar.gz
```

This will create the following subdirectories:
    SPA
        IMAPP
            algorithm
            ancillary
            station
            testdata
            testscripts
            wrapper

NOTE: The IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz file contains coefficient files required by the MODIS Cloud Optical Properties software module (MOD06OD). This module populates the cloud optical property arrays in the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) output product. In the absence of these coefficient files, the Cloud Optical Properties algorithm will not be run and the corresponding datasets in the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) output product will remain unpopulated. Note that MOD06OD tarball installation requires about 27 GB of space and if enabled, the Cloud Optical Properties processing requires significant amount of time.

Installing into an IPOPP Framework: This SPA can also be installed dynamically into an IPOPP framework to automate production of MODIS Cloudmask Level 2 (MOD35); MODIS Cloudtop Properties, Cloud Phase and Cloud Optical Properties Level 2 (MOD06); MODIS Atmospheric Profiles Level 2 (MOD07); MODIS Aerosol Level 2 (MOD04); and MODIS 3km Aerosol Level 2 (MOD04_3K) data products. The SPA installation process will install its SPA service(s) into IPOPP. An SPA service is an IPOPP agent that provides the mechanism necessary for running an SPA automatically within the IPOPP framework. Once this SPA is installed, users must enable the SPA service(s) corresponding to this SPA along with any other prerequisite SPA service(s). Instructions for installing an SPA and enabling its services are contained in the IPOPP User's Guide (available on the DRL Web Portal). The SPA services associated with this SPA are listed in Appendix A.

The installation process described in the IPOPP User's Guide will install the main SPA tarball (IMAPP_3.1_SPA_1.3.tar.gz).The optional IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz file will need to be installed with an additional step after the IPOPP SPA installation. Note that installation of this tarball will significantly increase the processing time. If you are not installing the MOD06OD tarball as part of the primary tarball installation, then make sure that the SPA services have been stopped before the installation (refer to IPOPP User's Guide if needed). Put the IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz file under $HOME/drl on the IPOPP machine and from that directory execute

    tar -xzf IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz

This will install the optional Cloud Optical Properties coefficient files.

Software Package Testing and Validation

The testscripts subdirectory contains test scripts that can be used to verify that your current installation of the SPA is working properly, as described below. Note that the optional IMAPP_3.1_SPA_1.3_testdata.tar.gz file is required to execute these testing procedures.

    Step 1: cd into the testscripts directory.
    Step 2: There is a script named run-imapp inside the testscripts directory.
    To run the IMAPP_SPA algorithm, use

       $ ./run-imapp

A successful execution usually requires about an hour or more (or about 15 minutes if the MOD06OD tarball is not installed), depending on the speed of your computer and the size of the input. If everything is working properly, the scripts will terminate with a message such as:

Output modis.cloudmask is /home/ipopp/drl/SPA/IMAPP/testdata/output/mod35.100601525.hdf
Output modis.cloudmaskbyte is /home/ipopp/drl/SPA/IMAPP/testdata/output/mask_byte1.100601525.hdf
Output modis.cloudtop is /home/ipopp/drl/SPA/IMAPP/testdata/output/mod06.100601525.hdf
Output modis.aerosols is /home/ipopp/drl/SPA/IMAPP/testdata/output/mod04.100601525.hdf
Output modis.aerosols3km is /home/ipopp/drl/SPA/IMAPP/testdata/output/mod04_3k.100601525.hdf
Output modis.atmprofile is /home/ipopp/drl/SPA/IMAPP/testdata/output/mod07.100601525.hdf

You can cd to the output directory to verify that the science products exist. Test output product(s) are available for comparison in the testdata/output directory. These test output product(s) were generated on a 64-bit PC architecture computer running CentOS 7. The output products serve as an indicator of expected program output. Use a comparison utility (such as diff, h5diff, etc.) to compare your output product(s) to those provided in the testdata/output directory. Locally generated files may differ slightly from the provided output files because of differences in machine architecture or operating systems.

NOTE: Datasets produced by the MODIS Cloud Optical Properties software module (MOD06OD) would remain unpopulated in the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) product if the IMAPP_3.1_SPA_1.3_MOD06OD_COEFF.tar.gz is not installed. In that case the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) output product generated by the testscript would differ from the corresponding test output product.

If there is a problem and the code terminates abnormally, the problem can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. Please report any errors that cannot be fixed to the DRL.

Program Operation

In order to run the package using your own input data, you can either use the run scripts within the wrapper subdirectories, or modify the test scripts within the testscripts subdirectory.

To Use the Run Scripts

Identify the 'run' scripts: The wrapper directory within this package contains one subdirectory named IMAPP. The subdirectory contains an executable called 'run'. Execute the 'run' to execute the IMAPP_SPA and create MODIS atmospheric products. Note that to execute 'run', you need to have java on your path.

Specify input parameters using <label value> pairs: To execute the 'run' script, you must supply the required input and output parameters. Input and output parameters are usually file paths or other values (e.g., an automatic search flag). Each parameter is specified on the command line by a <label value> pair. Labels are simply predefined names for parameters. Each label must be followed by its actual value. Each process has its own set of <label value> pairs that must be specified in order for it to execute. Some of these pairs are optional, meaning the process would still be able to execute even if that parameter is not supplied. The three types of <label value> pairs that the IMAPP_SPA uses are:

   a) Input file label/values. These are input file paths. Values are absolute or relative paths to the corresponding input file.

   b) Output file label/values. These are output files that are produced by the SPA. Values are absolute or relative paths of the files you want to generate.

   c) Parameter label/values. These are parameters that need to be passed into the SPA (e.g., platform name or scan time).

The following tables contain labels, and their descriptions, required by the IMAPP_SPA.

Input File Labels	Description	Source
modis.mxd021km	MODIS 1km L1B Calibrated Geolocated Radiances HDF file (MOD021KM, MYD021KM)	1. The MODISL1DB_SPA can be used to create Aqua/Terra MODIS Level 1B products.
modis.mxd02hkm (optional- may not be available for night swaths)	MODIS 500m L1B Calibrated Geolocated Radiances HDF file (MOD02HKM, MYD02HKM)	2. Real time Aqua/Terra MODIS Level 1B products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/terra/modis/MOD<021KM | 02HKM | 02QKM | 03>.yyDDDhhmmss.hdf (for Terra) and ftp://is.sci.gsfc.nasa.gov/gsfcdata/aqua/modis/MYD<021KM | 02HKM | 02QKM | 03>.yyDDDhhmmss.hdf (for Aqua)
modis.mxd02qkm (optional - may not be available for night swaths)	MODIS 250m L1B Calibrated Geolocated Radiances HDF file (MOD02QKM, MYD02QKM)	
modis.mxd03	MODIS Geolocation hdf file (MOD03, MYD03)	Where yy, DDD, hh, mm, ss represents the year, day of year,

Input File Labels	Description	Source
		hour, minute, second for the start of the swath. 3. Aqua/Terra MODIS Level 1B products for other locations and times are available for download at http://reverb.echo.nasa.gov/reverb/
leapsec (required for all products)	Leapsec ancillary file	DRL ftp site for leapsec files: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/leapsec.yyyymmddhh Where yyyy, mm, dd, hh represents the year, month, day, and hour for the leapsec ancillary file.
utcpole (required for all products)	Utcpole ancillary file	DRL ftp site for leapsec files: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/utcpole.yyyymmddhh Where yyyy, mm, dd, hh represents the year, month, day, and hour for the utcpole ancillary file.
ncep_met_1 (required for all products) ncep_met_1_prev (Optional) ncep_met_1_next (optional)	NCEP Numerical Weather Prediction Global Data Assimilation System (GDAS1, 6 hourly, 1 degree global) analysis field GRIdded Binary (GRIB) File in grib1 format.	Current GDAS Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gdas/gdas1.PGrbF00.yymmdd.hhz Current GFS Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gfs/gfs.thh.yymmdd.pgrbfxx Archived GDAS Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/gdas/gdas1.PGrbF00.yymmdd.hhz where yy, mm, dd, hh and xx represent the 2-digit year, month, date, analysis hour, and forecast time step respectively
ncep_met_2 (required for Profiles and Aerosol products)	NCEP Numerical Weather Prediction GRIdded Binary (GRIB) File. This can be either a Global Data Assimilation System (GDAS1, 6 hourly, 1 degree global) analysis field file or a Global Model Forecast Fields (GFS) file. The SPA requires GDAS and GFS files in grib1 format.	
ncep_met_3_before (required for Cloudtop Properties, Cloud Phase, Cloud Optical Properties	NCEP Numerical Weather Prediction GRIdded Binary (GRIB) File. This can be either a Global Data Assimilation System (GDAS1, 6 hourly, 1 degree global) analysis field file or a	

Input File Labels	Description	Source
product) ncep_met_3_after (required for Cloudtop Properties, Cloud Phase, Cloud Optical Properties product)	Global Model Forecast Fields (GFS) file. The SPA requires GDAS and GFS files in grib1 format.	
ssmi_nise (required for all products)	NSIDC NISE (Near-real time Ice and Snow Extent) (1 degree, global, daily)	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/nise/NISE_SSMIF13_yyyymmdd.HDFEOS Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/nise/NISE_SSMIF13_yyyymmdd.HDFEOS where yyyy, mm and dd represent the 4-digit year, month, and date respectively
ssmi_seaice (required for all products)	National Centers for Environmental Prediction (NCEP) sea ice concentration (1 degree, global, daily)	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/seaice/eng.yymmdd Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/seaice/eng.yymmdd where yy, mm and dd represent the 2-digit year, month, and date respectively
noaa_oisst (required for all products)	National Oceanic and Atmospheric Administration (NOAA) Optimum Interpolation Sea Surface Temperature (OISST) (1 degree, global, weekly)	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/sst/oisst.yyyymmdd Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/sst/oisst.yyyymmdd where yyyy, mm and dd represent the 4-digit year, month, and date respectively
noaa_toast (required for Aerosol products)	NOAA NCEP Total Ozone Analysis using SBUV/2 and TOV (TOAST) (daily, global)	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/toast/TOAST16_yymmdd.GRB Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/toast/TOAST16_yymmdd where yy, mm and dd represent the 2-digit

Input File Labels	Description	Source
		year, month, and date respectively
modis_csrb (required for Cloudtop product)	MODIS Clear Sky Radiance Bias (CSRB) 8 day composite products. Files are available for Terra and Aqua.	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/csrb/M<O|Y>CSR_B.AyyyyDDD.*.h5 Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/csrb/M<O|Y>DCSR_B.AyyyyDDD.*.h5 where yyyy, DDD represent the 4-digit year, and day-of-year of the start of the 8 day compositing period.

Parameter Labels	Description
platform	'aqua' or 'terra'
scandate	The start date of the L1B swath in yyDDD format where yy and DDD refers to the 2-digit year and day of the year respectively. If your input L1B files follow the standard Distributed Active Archive Center (DAAC) L1B file naming convention (e.g., M<O|Y>D021KM.AyyyyDDDhhmmss*.hdf; yyyy, DDD, hh, mm, ss represents the year, day of year, hour, minutes, seconds respectively for the start of the swath), this information can be found in the file name itself.
scantime	The start time of the L1B swath in hhmm format, where hh and mm refers to the 2-digit hour and 2-digit minutes respectively. If your input L1B files follow the standard DAAC L1B file naming convention (e.g., M<O|Y>D021KM.AyyyyDDDhhmmss*.hdf; yyyy, DDD, hh, mm, ss represents the year, day of year, hour, minutes, seconds respectively for the start of the swath), this information can be found in the file name itself.
cloudopt	'true' or 'false'. Default is 'true'. When 'false' the MODIS cloud optical property software (MOD06OD) software will not run and corresponding datasets will remain unpopulated in the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) product.
Output File Labels	**Description**
modis.cloudmask (optional)	MODIS Cloudmask Level 2 (MOD35) output HDF file
modis.cloudmaskbyte (optional)	MODIS Cloudmask first byte output HDF file
modis.aerosols (optional)	MODIS Aerosol Level 2 (MOD04) output HDF file
modis.aerosols3km	MODIS Aerosol 3km Level 2 output HDF file

(optional)	
modis.cloudtop (optional)	MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties Level 2 (MOD06) output HDF file
modis.atmprofile (optional)	MODIS Atmospheric Profiles Level 2 (MOD07) output HDF file

Execute the 'run': The following script shows an example of a command line to run the IMAPP_SPA algorithm from the testscripts directory:

```
$../wrapper/IMAPP/run \
modis.mxd021km ../testdata/input/MOD021KM.A2010060.1525.005.2010264213349.hdf \
modis.mxd02hkm ../testdata/input/MOD02HKM.A2010060.1525.005.2010264213349.hdf \
modis.mxd02qkm ../testdata/input/MOD02QKM.A2010060.1525.005.2010264213349.hdf \
modis.mxd03 ../testdata/input/MOD03.A2010060.1525.005.2010264155619.hdf \
platform terra \
scandate 10060 \
scantime 1525 \
ssmi_nise ../testdata/input/NISE_SSMIF13_20100301.HDFEOS \
ssmi_seaice ../testdata/input/eng.100301 \
ncep_met_1 ../testdata/input/gdas1.PGrbF00.100301.18z \
ncep_met_1_prev ../testdata/input/gdas1.PGrbF00.100301.18z \
ncep_met_1_next ../testdata/input/gdas1.PGrbF00.100302.00z \
ncep_met_2 ../testdata/input/gdas1.PGrbF00.100301.18z \
ncep_met_3_before ../testdata/input/gdas1.PGrbF00.100301.18z \
ncep_met_3_after ../testdata/input/gdas1.PGrbF00.100302.00z \
noaa_toast ../testdata/input/TOAST16_100301.GRB \
noaa_oisst ../testdata/input/oisst.20100303 \
modis_csrb ../testdata/input/MODCSR_B.A2010052.006.2015041040913.hdf \
leapsec ../testdata/input/leapsec.dat \
utcpole ../testdata/input/utcpole.dat \
modis.aerosols ../testdata/output/mod04.100601525.hdf \
modis.aerosols3km ../testdata/output/mod04_3k.100601525.hdf \
modis.cloudmask ../testdata/output/mod35.100601525.hdf \
modis.cloudmaskbyte ../testdata/output/mask_byte1.100601525.hdf \
modis.cloudtop ../testdata/output/mod06.100601525.hdf \
modis.atmprofile ../testdata/output/mod07.100601525.hdf
```

A successful execution usually requires about an hour or more (or about 15 minutes if the MOD06OD tarball is not installed), depending on the speed of your computer and the size of the input. If execution fails, you will see an error message indicating the cause of failure (e.g., a file cannot be found, or a label cannot be recognized). Correct it and run again. If the problem has some other cause, it can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile* and can be deleted after execution. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous

results. The 'run' can be executed from any directory the user chooses. This can be done by prefixing it with the file path for the 'run' script.

NOTES:

1. **Selective product processing:**   The IMAPP_SPA will produce only those atmospheric products whose output labels were specified on the command line. For example, specifying only modis.cloudmask and modis.atmprofile labels on the command line will result in generation of only the cloudmask and profiles products. Output file format information for each product can be found in /SPA/IMAPP/algorithm/doc.

2. **Ancillary input files:** The SPA needs ancillaries to be provided on the command line. Some ancillaries are manadatory for all products, others are required for particular products only. Please refer to the Inputs Table above. Recommendations for choosing ancillary input files for a particular L1B granule are provided below for each ancillary label:

   - **leapsec and utcpole:** Leapsec and utcpole ancillaries are required for all products. Always use the latest leapsec and utcpole file regardless of the scantime.

   - **ssmi_nise & ssmi_seaice:** The ssmi_nise and ssmi_seaice files are required for all products. The dates for the NSIDC Near-real time Ice and Snow Extent (NISE) and NCEP sea ice datasets should be as close as possible to the dates of the L1B granules. It is recommended to use an ancillary file that is within ±14 days of the granule time. The dates for the NISE and NCEP Sea Ice ancillary files are encoded in the filenames as NISE_SSMIF13_yyyymmdd.HDFEOS and eng.yymmdd respectively.

   - **noaa_oisst:** The noaa_oisst file is required for all products. The date of the Optimum Interpolation Sea Surface Temperature (OISST) weekly ancillary file should also correspond as closely as possible to the L1B scan time. It is recommended to use an OISST ancillary file that is within ±28 days of the granule time. The date for the OISST file is encoded in the filename as oisst.yyyymmdd.

   - **noaa_toast:** The noaa_toast file is required only for the Aerosol and Aerosol 3km (MOD04) products. The dates of the ozone data should be as close as possible to the dates of the L1B granules. It is recommended to use TOAST ancillary files that are within ±14 days of the granule time. The dates for the TOAST ozone ancillary files are encoded in the filenames as TOAST16_yymmdd.GRB.

   - **ncep_met_1, ncep_met_1_prev, ncep_met_1_next:** ncep_met_1 is required for all products. ncep_met_1_prev and ncep_met_1_next ancillaries are optional, but recommended. Global Data Assimilation System (GDAS) files should be used for these labels. GDAS files are produced every 6 hours at 00, 06, 12, and 18 UTC daily. The time, date and hour of the GDAS files in grib1 or grib2 format can be

found in the filename. For example, gdas1.PGrbF00.070210.18z corresponds to February 10, 2007, 1800 UTC. When choosing the GDAS ancillary file for ncep_met_1, choose one which is closer in time (±3 hours) rather than the date. For example if you have an L1B granule at 1700 UTC, the GDAS file for 1800 hours on the same day would be the best match. However, if that is not available, it would be preferable to use the GDAS file corresponding to 1800 UTC for the day before rather than the GDAS file at 1200 UTC for the same day. It is recommended to use a GDAS file for ncep_met_1 that is within ±7 days of the granule time. ncep_met_1_prev should be assigned to the same GDAS file as ncep_met_1 (or can remain unassigned since ncep_met_1_prev is optional) ncep_met_1_next is to be chosen based on ncep_met_1 GDAS time. ncep_met_1_next should be the closest GDAS file with time > ncep_met_1 time. For example if ncep_met_1= gdas1.PGrbF00.070210.18z, ncep_met_1_prev is going to be gdas1.PGrbF00.070210.18z and ncep_met_1_next is going to be gdas1.PGrbF00.070211.00z.

- **ncep_met_2:** The ncep_met_2 file is required for Profiles and Aerosol products. Either GDAS or Global Model Forecast Fields (GFS) files may be used for this label. Try to use a GDAS file that is within ±3 hours of the L1B granule. If that file is not available (as is often the case for real-time processing), use a GFS file instead. The naming convention for grib1 GFS files is gfs.thh.yymmdd.pgrbfxx (Here yymmddd and hh represent analysis time, and xx represents forecast time step). Thus a file named gfs.t12.100201.pgrbf03 corresponds to 1500 hours (12+3) UTC on February 1, 2010. If you have to choose GFS data as input, you should attempt to use a file that is within ±1.5 hours of the L1B file. If there is more than one such GFS file, use the one with the smaller forecast time step. For example, if your data time is 15 UTC, you should try to use the 3 hour forecast field from the 1200 UTC model run, instead of the 9 hour forecast field from the 0600 UTC run. If no GDAS or GFS file is available using the above logic, use a GDAS file that is closest in time but within ±7 days of the granule time.

- **ncep_met_3_before & ncep_met_3_after:** ncep_met_3_before and ncep_met_3_after ancillaries are required only for the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) product. ncep_met_3_before should be the closest GDAS within the 6 hours prior to the L1B time. If a GDAS file is not found use a GFS file within the 3 hours prior to the L1B time. If you have more than one GFS file satisfying the latter criterion, use the one with the smallest forecast step. If a GDAS/GFS file is not found for the same day as the L1B, you may use a GDAS file from within ±7 days as long as its time is within the 6 hours before the L1B time. The logic for selecting a ncep_met_3_after file is similar except that it should be after the L1B time.

- **modis_csrb:** The modis_csrb file is required only for the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) product. The starting date for the 8-day MODIS Clear Sky Radiance Bias (CSRB) dataset should be as close as possible to 8 days prior to the date of the L1B granules. Make sure that

the CSRB file you use (Terra or Aqua) matches the platform corresponding to your L1B files. The date and platform of a CSRB file is encoded in the filename as M<Y|O>DCSR_B.Ayyyyddd.005.*.hdf (Y-Aqua; O-Terra).

3. **Aerosols:** The IMAPP_SPA will not produce the aerosol products if there is an insufficient number of daytime scans

4. **Cloud Optical Properties Datasets:** The IMAPP_SPA will not populate the Cloud Optical Properties Datasets within the MODIS Cloudtop Properties, Cloud Phase, Cloud Optical Properties (MOD06) product if there is an insufficient number of daytime scans

To Use the Scripts in the testscripts Directory
One simple way to run the algorithms from the directory of your choice using your own data is to copy the run-imapp script from the testscripts directory to the selected directory. Change the values of the variables like WRAPPERHOME, INPUTHOME and OUTPUTHOME to reflect the file paths of the wrapper directories and the input/output file paths. Then modify the input/output file name variables. Run the script to process your data.

Appendix A
SPA Services

Installation of this SPA in IPOPP mode will make the SPA services listed in Table A-1 available to IPOPP. These SPA services along with any other prerequisite SPA services (listed in Table A-2) will need to be enabled to allow IPOPP to automate production of the IMAPP_SPA data products. Furthermore, users who wish to generate image products from the data products generated by this SPA will need to enable the image-generating SPA services listed in Table A-3. The SPAs containing the prerequisite and the image-generating SPA services listed in Tables A-2 and A-3 can be downloaded from the DRL Web Portal, in case they are not already available in your IPOPP installation. Details about these other SPAs are available in the respective SPA User's Guides. Please refer to the IPOPP User's Guide for instructions on how to install an SPA in IPOPP and enable the corresponding SPA services.

Table A-1. SPA Services

SPA services for this SPA	Data Products produced	
IMAPP	**Product Name**	**Destination (when installed in IPOPP)**
	MODIS Cloudmask Level 2 (MOD35)	/raid/pub/gsfcdata/<terra|aqua>/modis/level2/CLOUDMASK.yyDDDhhmmss.hdf[1]
	MODIS Atmospheric Profiles Level 2 (MOD07)	/raid/pub/gsfcdata/<terra|aqua>/modis/level2/PROFILES.yyDDDhhmmss.hdf[1]
	MODIS Aerosol Level 2 (MOD04) (Daytime only)	/raid/pub/gsfcdata/<terra|aqua>/modis/level2/AEROSOL.yyDDDhhmmss.hdf[1]
	MODIS Aerosol 3km Level 2 (MOD04_3K) (Daytime only)	/raid/pub/gsfcdata/<terra|aqua>/modis/level2/AEROSOL3KM.yyDDDhhmmss.hdf[1]
IMAPP-Cloudtop	**Product Name**	**Destination (when installed in IPOPP)**
	MODIS Cloudtop Properties, Cloud Phase, and Cloud Optical Properties Level 2 (MOD06) (The Cloud Optical Properties datasets are Daytime only).	/raid/pub/gsfcdata/<terra|aqua>/modis/level2/CLOUDTOP.yyDDDhhmmss.hdf[1]

[1] Where *yy*, *DDD*, *hh, mm, ss* represents the 2-digit year, day of year, hour, minute and seconds respectively for the start of swath

Table A-2. Prerequisite SPA services

Prerequisite SPA services	SPA in which they are available
gbad	GBAD_SPA
l0l1terra	MODISL1DB_SPA
l0l1aqua	MODISL1DB_SPA
l1atob	MODISL1DB_SPA

Table A-3. Image-generating SPA services

Image-generating SPA services	SPA in which they are available
ctp-geotiff	H2G_SPA
cloudmask-geotiff	H2G_SPA
aerosols-geotiff	H2G_SPA
irphase-geotiff	H2G_SPA
atmprofile-geotiff	H2G_SPA

NOTE: Please refer to the H2G_SPA User's Guide for more details about the image products, including their locations and filename patterns when they are generated in IPOPP.